# Studying the alignment of cellulose nanoparticles under complex deformation fields by microfluidics and SAXS

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Within the last decade, cellulose-based nanomaterials have been extensively studied due to their unique physicochemical properties as well as their bio-derived nature, their abundance and the possibility to extract large quantities from wood in an economically viable process [1]. More specifically, the mechanical properties are rather impressive, in particular if measured in the direction of the oriented axis, which in turn, means that the properties of an object are highly dependent of the alignment or anisotropy of nanocellulose-containing materials [2]. Cellulose nanofibrils (CNFs) (length >1 μm, cross-section ca. 5 nm) are flexible and have large aspect ratios. At higher concentrations of 1-2% CNF, a highly entangled network is formed, which affects the capability for molecules to align to each other and results in complex rheological behavior.

Controlling alignment in nanocellulose dispersions using flow is of high interest due to the unique physicochemical properties of nanocellulose mentioned above, which make them suitable in a wide range of applications including additive manufacturing, aka. 3D printing. 3D printing is a promising tool to produce a 3D hierarchical structure with a controlled architecture spanning from nano- to macroscale. In particular, the controlled alignment of nanofibrils is of high interest, since their anisotropy in the structure brings heterogeneous mechanical properties, thus by controlling the orientation of the nano-entities, tailored properties can be achieved. The structure and thereby properties of the final material depend strongly on the process parameters. In such processes, complex deformations coupled with concentration, aspect ratio and flexibility to produce an intricate effect on the anisotropic structure and create new material properties.

Here, we present our latest results on cellulose nanofibril suspensions in microfluidic channels that resemble the shape of the 3D printing nozzle, and in the recently developed fluidic four-roll mill (FFoRM) device [3] that enables us to create arbitrary flows in it. We probed the nanoscale structure and alignment of nanocellulose suspensions with small angle X-ray scattering (SAXS) by raster scanning a focused beam over the region of interest gaining spatially resolved information. Scanning SAXS measurements [4] were carried out at the cSAXS beamline, Paul Scherrer Institut, Switzerland.

References:

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